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ABSTRACT

There are three kinds of master's degrees in the natural sciences: (1) the booby prize, for students who during their graduate career are disqualified for academic reasons from continuing to the Ph.D.; (2) the automatic degree with no thesis requirement and generally awarded after accumulating a certain number of credits; and (3) the degree that requires a thesis and a certain level of competence in course work. This last degree is often awarded by independent colleges which either do not have a Ph.D. program, or are just thinking about getting one underway, and the student with this degree has often to go to a major university for the completion of his doctorate. The situation is different for engineering, where the pursuit of the master's degree is generally a part-time occupation, and where the degree itself has been downgraded over the last 5 years. The Ph.D., much more theoretical in nature, is being pushed in engineering. This is only acceptable if the fact is not overlooked that the nuts and bolts engineer is as important as his theoretical counterpart. A positive sign is the development of some hyphenated degrees, combining engineering and the natural sciences with some of the social sciences, preparing students to deal more effectively with the social fabric of our society. (AF)

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THE MASTER'S IN SCIENCE AND ENGINEERING*

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DR. HENRY V. BOHM: Well, when I started to prepare this talk last week I started to pull out all of my old physics research slides looking for some pretty curves that I could re-label, and then when I saw the slide facilities this afternoon, I threw them all out, so I am going to save some time by not showing them.

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My topic is to talk about the master's degree in science and engineering and I want to start with a rather farfetched comparison.

Let me compare the bachelor's degree to Jane Fonda; young, attractive, maybe a little hippie.

Let me compare the Ph.D. to Raquel Welch; it requires somewhat more development, somewhat more endowment.

And then I think it is appropriate to compare the master's degree to Phyllis Diller.

(Laughter.)

Now, I take the assignment to cover all flavors of engineering and the natural sciences, both biological and physical sciences. I think there are some generalizations one can make and some points which split them apart.

Leaving engineering aside for a moment, there are, I think, three kinds of master's degrees. The first is the booby prize awarded at many of the Ph.D.-granting institutions to those doctoral aspirants who, for a variety of reasons--usually, but not always including intellectual capacity--cannot make it through the Ph.D. Most recently that's a degree without a formal

thesis requirement in which the student has spent too much time because the administrative machinery at some level either didn't have the heart or the guts to say goodbye to the man at an earlier stage; or didn't insist on a tighter time schedule for a doctoral qualifying or preliminary exam.

I suggest that's an area in which students--and certainly that's true of students at my institution--often present very legitimate complaints.

The fact that it is not easy to arrive at a judgment of the student's capacity early in his graduate career, particularly if he comes with a less than average quality or quantity of preparation is an explanation, but it is not a valid excuse.

In my experience most students are not made specifically and explicitly aware, right from the start, how long they may be left in limbo before a definite decision is arrived at to stop them at the master's degree or to permit them to go on to the Ph.D.

The second kind of master's degree is the kind that at some schools, either inevitably or at least for the less than outstanding students, is expected to come en route to the Ph.D. It usually also has no thesis

requirement, and most often it is a matter of accumulating a certain number of credits at which time the departmental and university machinery grinds into action and eventually spits out a master's degree.

I think there is something to be said for this kind of a master's degree compared with the one I just described previously.

If the student is told at that point, "From here on in you are gambling on your own time, whether you can make it through the Ph.D. You may, in fact, be investing one, two, or even three years and at the end of that time have nothing more to show for your time." I think that's fair.

There is another use for this kind of master's degree, particularly in schools such as my own where we have large numbers of first-generation-in-college students.

For the student who is first in his family to earn a bachelor's degree, one sometimes has to raise his sights gradually. If you talk to him about undertaking a Ph.D. program in his senior undergraduate year, in my experience you may frequently frighten the man off from undertaking any graduate study, particularly because

of family pressure. The attitude at home, as I have seen it, is often described by a feeling, "You've climbed the mountain, you've got your bachelor's degree. Now go out and get a better job than your cousin who went to work after high school." And the family support and attitude as an undergraduate is, you know, "Let's help him, let's get him through." When he gets into graduate school, particularly in the sciences which are regarded as esoteric and not useful like law or medicine or social work, the family attitude very quickly often becomes one of suspicion that the graduate student is a failure or a loafer or who just doesn't have the guts to go out and support himself in a normal job.

So the master's degree which comes relatively quickly and, to a certain extent, automatically with a certain course completion is a good level to which you raise such a student's sights initially. When you have got him there, you can raise them higher. It is a level which the family often understands.

The third kind of master's degree is that given often by independent colleges which either do not have a Ph.D. program, or are just thinking about getting one underway. These, in general, are the master's degrees

in the best traditional sense of requiring the small Ph.D.-type thesis, a certain level of competence in course work, a close personal interaction between a small number of students and the small number of faculty members of the department and, perhaps, neighboring departments.

Typically the student will take this master's degree at the same school where he took his undergraduate work and will then expect to go on to one of the major universities for his Ph.D. work.

While I applaud the substance of this master's degree in which a student is likely to spend two or two and a half, even three years, frequently it is coupled with some sort of an assistant instructor assignment in the department.

While I applaud that in substance, I am sorry to say that I think in many cases it is a disservice to the student.

In the first place, the research quality and sophistication that the student--and I am speaking of the sciences here--spends a substantial amount of time on at the small school can usually be surpassed at the Ph.D. institution in a much shorter period of time.

Thus, when he gets to the major institution

for his doctoral work, in the end he finds that in summing up the time that he spent from the bachelor's to the doctor's degree, at least one year if not one and one-half or two years have disappeared without a trace compared to his contemporary doctoral candidate colleagues who started in at that institution.

Additionally at some schools and in some scientific disciplines--let me use organic chemistry as the whipping boy--the student who goes through this master's degree and then goes on to his doctoral place of work will find himself at an initial disadvantage at the Ph.D. school in that he has not commenced preliminary work in the research laboratory of his proposed Ph.D. professor at the same early stage as those students who started in at that school right after the bachelor's degree.

Now, there may be some other values to the kind of master's degree I have just described. One is for the student who, with the bachelor's degree, is simply not ready to be thrown into a big pond.

Another one is for the student who would like to try out a long-term career of serving at a primarily four-year type of college, and in these two

years that he spends as a master's degree student he gains an insight, certainly much more than he ever would or did as an undergraduate, into the kind of a college faculty and can thereafter make a better decision whether such a career is likely to appeal to him.

These, then, are the three prototype master's degrees in the sciences; the booby prize, the automatic, and the tough one.

In my description I have certainly separated them very completely, perhaps to the point of drawing caricatures, but I think perhaps you recognize the types.

I should note one more item; that is that in different departments at the same university you may, in fact, find examples of each one, even though I characterized one as being primarily small and independent schools.

For engineering, of course, the milieu is quite different. To the best of my ability to observe the master's degree, particularly as a professional degree in engineering worthy of full-time study, in the last five years it has suffered a good deal of downgrading. And the Ph.D. in engineering, much more theoretical

in nature, has and is being pushed hard in engineering.

I find myself regretting this development, particularly in view of Dr. Falk's remarks this afternoon. I regret it even though it means turning out engineers with greater prestige, vis-a-vis their scientific colleagues, and perhaps more substantively, engineers who are more educated to think independently and who can better communicate with their scientific and occasionally their social science colleagues than the earlier version could.

I think a need exists, and it has been demonstrated for this more highfalutin type of Ph.D. engineer. But on the other hand it seems to me that the engineer who can read steamtables in order to design and build and operate a turboelectric power plant, atomic energy or not, and the engineers who still know how to set up the calculations, long and drawnout, necessary to design a--I don't know, a Verrazano Narrows Bridge is still a useful guy.

What I am saying is that the trend I observe in engineering schools is to educate graduate students in a much more theoretical and esoteric set of problems than previously. That's fine, provided that

neither the students nor the faculty lose sight of the fact that a good many nuts and bolts engineers are, and still will be needed. These are guys who can organize the task of draining a swamp, a Miami Beach swamp--it's kind of nice that they did that some years ago. Or the guys who know what switches to throw in this enormous interlocked national electric power network that we are moving toward, so that when I blow a fuse in my home in Detroit, Salt Lake City or some other place isn't without lights for a week.

This is not the kind of engineer I think that the Ph.D. engineer is being prepared for.

Many of you will have seen or heard some of the statistics recently developed by Chancellor Carter. In a much oversimplified way, as I understand his projections, for the '70s we are turning out Ph.Ds in engineering and the sciences at a roughly sufficient rate to meet the needs of our society. This afternoon's program certainly addressed itself to this topic.

I am certain that doesn't mean we are turning out exactly the right distribution or always good quality. But I think one is led to take a look at the master's degree as a useful level of education accomplishment,

particularly for people engaged in the applied sciences, the development and the operating end of the business as contrasted to pure research.

Even in pure research there is a gap in available people, in highly skilled and trained technicians--supertechnicians, if you like--which can be filled and has in the past been filled at the master's degree level.

A trend that I think may be increasing for better or for worse is that the part-time master's degree student in the sciences and engineering; that is, the trend toward part-time study for the master's degree level. Indeed, in engineering it is not uncommon today, and certainly outside of the sciences and engineering in the professional educational field, it is more normal, rather than the exceptional mode of making progress.

Personally I don't necessarily applaud this development but I do think, particularly in view of the limited funds available for graduate research and the support of students in the sciences, this trend will increase during the present decade.

A natural corollary of part-time study towards the master's degree seems to me to be a fatal de-emphasis of the research and thesis part of the

master's degree requirement. I don't claim that that is necessarily good, but I think we all need to be aware of it.

Steve Spurr, when he was speaking at a recent conference on changing patterns in graduate education spoke about flexible entry and exit ports for students undertaking study at the graduate level. I think part-time study, even with those characteristics which are undesirable, is a necessary part of that flexibility.

The hopeful sign I think I see, perhaps more in engineering and elsewhere, but also in the sciences in general, is that maybe at the master's level we are beginning to develop some hyphenated degrees; that is to say, some master's degrees in engineering and the sciences hyphenated with some of the social sciences; the kind of modern engineering and applied science problem that would appear to be relevant today and perhaps for the next 20 years often requires a greater understanding, or at least a greater awareness of the social fabric of our society than has been traditionally provided by the graduate education in the sciences and engineering that we have offered the students in the past 30 or 40 years.

What is more true is that apart from the relatively small number of deep thinkers, frontier researchers, Ph.D.-type people, the need, the opportunities, and the openings for really large numbers of operationally qualified people are there, and they are growing. In my estimation these are the people that we now think of as being at the master's degree level.

Put a little differently, these are the practitioners and the practitioners' degrees of which Dr. Reitz spoke this afternoon.

I want to emphasize very strongly that when I speak of these hyphenated degrees, I think they are only useful if they have real substance and not just P.R. sound and fury.

An environmental master's degree cannot be just a handful of old elementary biology courses mixed in equal or unequal proportion with a handful of elementary economics and sociology courses. That's just the education of a dilettante--or perhaps you will allow me to say of a Phyllis Dillerante.

(Laughter.)

I would hope that these master's degree level programs, if and as they develop, will tend to be

more academic than professional in the sense that they will be reasonably broad and teach the student how to think about the problem of interest, the problems of interest rather than merely enabling the student to become well-versed in one very small, very specific area.

The allied health care area is an area of great need and of some development in this kind of degree.

Mr. Chairman, I have not quoted any figures, shown graphs or slides, but rather rambled on in an unscientific fashion. I wouldn't feel quite right without quoting at least one reasonably quantitative comparison. As badly and unevenly as we collectively turn out master's degree students in the sciences and engineering, I think the following very rough comparison is a sign that things perhaps could be worse.

If over the last three years one takes the ratios cf master's to bachelor's degrees in all of the traditional university disciplines lumped together, and the ratio of the Ph.D. to the bachelor's degrees awarded in these same areas, in the first case one arrives at about a 25 percent number; in the second case, at about 3.4 percent.

And if one goes through the same exercise specifically for the sciences and engineering, as I have used these terms here, the biological and physical sciences, math and engineering, one arrives at a master's to bachelor's degree ratio of about 40 to 45 percent; and a Ph.D. to bachelor's ratio of about 12 percent.

In other words, science and engineering students continue into master's degree work with a frequency almost twice as high as those in all of the traditional disciplines combined.

Perhaps one can interpret this as indicating that the science and engineering students find at least some things worthwhile in these graduate programs more often than other students do in their graduate programs.

On the other hand perhaps it only means that Phyllis Diller isn't all sour.